10-19-07

IFW

Petroleum Composites

1 Berryfrost Lane, The Woodlands, TX 77380
Phone: 281 296-6805 E-mail: pcomp@peoplepc.com

Appl. No. : 10/764,634

Confirmation : No. 9083

Applicant : Jerry Gene Williams

Filed : 1/23/2004

Examiner : Juan D. Valentin

Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

Subject: Patent Application No. 10/764,635

Dear Mr. Valentin:

This correspondence is in response to your comments concerning the subject patent application. Thank you for this opportunity to reply.

First, I would like to comment on patent 7,194,913 which was issued on March 27, 2007, a few days after I submitted my recent revisions. I have closely reviewed Patent 7,194,913 entitled "Apparatuses and Methods for Monitoring Stress In Steel Catenary Risers" and offer the following assessment.

I reviewed the original application for this patent posted on the web and the patent is little changed from the original application document. As an observation, I am surprised at the lack of conformity in the patent with USPTO regulations. The patent is hard to read because the version posted on the web lacks numbers on figures referenced in the text. The text describes colors on the figures which USPTO regulations do not allow. And as described below, fundamental errors are in the text description of the fiber optics technology. I believe the number 2000 on page 2, line 9 is a typo error.

The primary objective of Patent 7,194,913 is to describe an apparatus which can be used to measure the stress-strain in a catenary riser in order to compare the information with the S-N fatigue data for the material used to construct the riser and thus predict the potential fatigue life and failure of the catenary riser. Multiple sets of sensors are used to obtain data at different places along the length of the catenary riser and to allow calculation of the maximum stress-strain.

The 7,194,913 patent intent is measurement of the maximum stress-strain on the riser and to compare experimental results with S-N fatigue data (see for example: P. 7 line 58-67, P. 5, line 6-7, P. 5, line 20, P. 5, line 22-24, P. 8 line 55, P. 13 line 33-34, P. 15 line 12, P. 16 line 14-17, and P. 17, line 23-33). The patent does not address defining the vibration characteristics. As described in my patent application, my method uses multiple sets of optical fiber sensor oriented

along the length of the pipe and located on opposite sides of a line drawn perpendicular to the longitudinal axis and through the centroid of the pipe. Vibration characteristics can include: vibration frequency, node to node wave length and the magnitude of the imposed peak bending strain.

The description of OTDR technology given on Page 9 of patent 7,194,913 exhibits a lack of understanding of OTDR fiber optics technology. As described in my patent application, "OTDR is a time of flight method which measures spatial positions along an optical fiber by launching brief pulses of laser light into one end of the fiber and then detecting the subsequent reflections at reflective interfaces inserted along the length of the fiber. The principles of the use of optical fibers technology to measure strain are well established." Patent 7,194,913 describes an OTDR method to measure strain through "analysis of back scattered light" (Page 9, line 28). Even though an incorrect description of OTDR fiber optics technology is given, Patent 7,194,913 claim is for measurements of maximum stress-strain for purposes of fatigue assessment (page 9, line 27), not to measure vibration characteristics. The inventors also conclude that OTDR is not a sufficiently sensitive to measure the strain required for fatigue monitoring, but try to cover their lack of success with a blanket statement that someday back-scattering might work (P. 9 line 53-60).

I asked a Ph.D. physicist actively involved in fiber optics technology to review page 9 of patent 7,194,913. The following is his response.

> "The idea that strain influences the quantity of backscattered light (the amount of Rayleigh scattering) in ordinary optical fiber shows a poor understanding of the nature of backscatter. No wonder "the OTDR failed to record strains in the fiber" (column 9, line 47). You would need a highly crystalline glass fiber to see stain-induced changes in backscatter, and my suspicion is that the backscatter intensity might actually decrease. Furthermore, staining crystalline glass would be very difficult without breaking the fiber. Further-furthermore, a coiled fiber has tensile strain on the outer radius and compressive strain on the inner radius. I think my earlier comment must have been along the lines of what a poorly conceived and designed experiment this must have been. There are certainly no references to Time Of Flight - based strain measurements in columns 9 and 10."

Patent 7,194,913 primary claims describe a special collar clamped around a carenary riser which incorporates optical fibers to measure strain. Nowhere in the patent including claims does the inventors claim to measure bending strain and the text and figures neither describe nor show the required location to make such measurements.

There are four primary claims (1, 4, 11, and 13) in Patent 7,194,913. Claims 1 addresses the use of strain monitoring with externally applied clamps containing optical fibers to make strain measurement. The emphasis of Claim 4 is measurement of strain and fatigue in the area of touch down on the sea bed. Claim 11 is hard to understand but seems to involves the use of optical fibers and an instrumented curves plate. Claim 13 is also associated with the use of an optical fiber instrumented clamp. In my patent application the optical fibers are attached to the longitudinal axis of the structure and does not involve clamps.

Since Patent 7,194,913 was issued after my revisions were submitted, it seems appropriate to reference it in my patent. Please advise how I should address this.

In response to our discussions, I would like to propose the following revisions to the claims for my patent application. Changes from the previous claims are underlined.

What is claimed is:

43. A method for measuring the vibration characteristics of long slender structures subjected to dynamic disturbances imposed by water or wind generated dynamic loads otherwise known as vortex induced vibrations (VIV) comprising:

projecting laser light into a single or plurality of independent optical fibers fastened at discrete locations along the longitudinal axis of the long slender structure;

reflecting said projected laser light from optical reflective interfaces placed at selected locations along the length of each optical fiber(s) creating a reflected laser light data signal;

collecting through a fiber optics or electronic data transmission link said reflected laser data signal;

receiving and analyzing said collected laser light data signal at electronic optical signal monitoring instrumentation;

determining critical strains within the predetermined segments along the length of said long slender structures;

calculating at least one vibration characteristic from the determined critical strains in order to permit mitigation of damaging effects caused by VIV along said long slender

structures through the use of corrective action.

44. The system of claim 43, wherein vibration characteristics include: vibration frequency, vibration amplitude, node to node wave length and the magnitude of the imposed peak bending strains.

45. The system of claim 43, wherein the optical fibers are located along the longitudinal axis and near the exterior or interior surface of a long slender tubular structure.

46. The system of claim 43, wherein longitudinal oriented optical fibers are located at opposite ends of an imaginary line drawn perpendicular to the longitudinal axis of the long slender structure and through the structure centroid thereby enabling the measurement of bending strains imposed during dynamic loading.

47. The system of claim 43, to include multiple set of longitudinally oriented optical fibers located on the structure near opposite ends of an imaginary line drawn perpendicular to the longitudinal axis of the long slender structure and through the structure centroid designed to capture the maximum bending strains imposed during dynamic loading.

48. The system of claim 43, used to measure the bending strain imposed by vortex induced vibrations (VIV) experienced by metal or composite production and drilling risers, tubing, ropes, and cables deployed in offshore operations in the oil industry.

49. The system of claim 43, which provides the information needed to take corrective actions to permit mitigation of potentially damaging effects of vortex induced vibrations (VIV) in long slender tubular structures used in offshore petroleum drilling and production operations including adjusting the axial tension and adding strakes, shrouds and fairings.

50. The system of claim 43, wherein the electronic optical signal monitoring instrument is capable of measuring the time of flight of light reflected from an optical reflective interface and the information is interpreted to measure strain.

51. The system of claim 50, wherein the time of flight measurement instrument is an optical time domain reflectometry instrument.

52. The system of claim 50, wherein the time of flight measurement instrument is an optical frequency domain reflectometry instrument.

53. The system of claim 43, wherein an independent longitudinal oriented optical fiber is positioned to traverse back and forth along the length of the long slender structure to provide greater sensitivity to the measurement of strain using time of flight instrumentation.

54. The system of claim 43, wherein the electronic optical signal monitoring instrument measures strain using Bragg diffraction gratings.

55. The system of claim 43, wherein the optical fiber is rigidly attached to the exterior or interior surface of a metal or composite tubular using a bonding agent and the optical fiber is

protected from damage by hazards imposed in the operating environment by a polymeric or elastomeric external layer.

56. A system of claim 43 wherein the optical fiber used to measure strain is constructed of glass or plastic.

57. A system of claim 43 wherein the long slender structure is a rope or cable and the bending strain and vibration characteristics measured provide the information needed to take action to permit mitigation of the potentially damaging effects of wind or water generated dynamic disturbances.

58. A method for measuring the bending and buckling characteristics of spoolable metal or composite pipe subjected to axial compressive loading during injection into a small diameter annulus comprising:

projecting laser light into a single or plurality of independent optical fibers fastened at discrete locations along the longitudinal axis of the spoolable metal or composite pipe;

reflecting said projected laser light from optical reflective interfaces placed at selected locations along the length of each optical fiber(s) creating a reflected laser light data signal;

collecting through a fiber optics or electronic data transmission link said reflected laser data signal;

receiving and analyzing said collected laser light data signal at electronic optical

signal monitoring instrumentation;

determining critical strains within the predetermined segments along the length of said metal or composite spoolable pipe;

calculating pending spoolable pipe buckling characteristics from the determined critical strains to allow corrective action to be taken to prevent helical buckling lock-up of the pipe inside the small diameter annulus.

59. The system of claim 58, wherein longitudinal oriented optical fibers are located at opposite ends of an imaginary line drawn perpendicular to the longitudinal axis of the spoolable pipe and through the pipe centroid thereby enabling the measurement of bending strains imposed during injection of the spoolable pipe into a small diameter annulus such as an oil well or bore hole.

60. The system of claim 58, to include multiple set of longitudinally oriented optical fibers located at opposite ends of an imaginary line drawn perpendicular to the longitudinal axis of the spoolable pipe and through the pipe centroid designed to capture the maximum bending strains imposed during deployment into a small diameter annulus.

61. The system of claim 58, wherein the bending strain in the spoolable pipe is measured as the spoolable pipe buckles into numerous short wave length spiral and helical buckles inside the annulus in response to the axial compressive force imposed to push the spoolable pipe into the annulus by a coiled tubing injector or other injection apparatus.

62. The buckling characteristics of claim 58, wherein bending strain information provides the information necessary to take action <u>including reducing the applied axial compressive force in order</u> to prevent the spoolable pipe from entering a condition of lock-up inside a small diameter annulus.

63. The system of claim 58, wherein the electronic optical signal monitoring instrument is an Optical Time Domain Reflectometer strain measurement instrument

64. The system of claim 58, wherein the electronic optical signal monitoring instrument is an Optical Frequency Domain Reflectometer strain measurement instrument.

65. The system of claim 58, wherein the electronic optical signal monitoring instrument is a Bragg diffraction gratings strain measurement instrument.

66. The system of claim 58, wherein an independent longitudinal oriented optical fiber traverses back and forth along the length of the spoolable pipe to provide greater sensitivity to the measurement of strain using time of flight strain measurement instrumentation.

67. The system of claim 58, wherein the optical fiber is located along the longitudinal axis of the spoolable pipe near the exterior surface of the pipe and is rigidly attached to the exterior surface of a metal or composite spoolable pipe using a bonding agent and the optical fiber is protected from damage by hazards imposed in the operating environment by an overlay of a polymeric or elastomeric external layer.

68. The system of claim 58, wherein the optical fibers are located along the longitudinal axis of the spoolable pipe and near the interior surface of the pipe.

69. The system of claim 58 wherein the optical fibers are attached to the interior of the spoolable pipe following the spoolable pipe fabrication by inserting a cylindrical foil carrier consisting of an outer layer of adhesive and with longitudinal optical fiber integrated into the foil followed by pressurization of the interior of the foil with a hot fluid or gas to cure the adhesive to bond the foil to the spoolable pipe.

70. The system of claim 58, wherein the optical fiber is integrated into the body of the composite spoolable pipe during manufacture.

71. The system of claim 58, wherein strain measurements are made in the region of deployment onto and off of a storage spool and provide information needed to assess the structural integrity of the spoolable steel or composite pipe.

I would also like to make a correction to paragraph [0006] of the specification as shown in red below:

[0006] One very effective way of monitoring structural performance is to measure the strain response to load. Strain can be compared to design predictions and monitoring the change in strain during service can be a very effective indicator of structural degradation due to overload, impact, environmental degradation or other factors. Advanced fiber optics technology is a reliable in situ method not only to measure peak strain values but bending strain information can

[redacted]or example, [redacted] be used to measure the magnitude, period, and frequency of Vortex Induced Vibrations (VIV) of risers used in offshore petroleum drilling and production operations; and more particularly, through engineering interpretation of the bending strain data to predict the fatigue life of the tubular and to allow active controls to be used to mitigate the potential damage from VIV. In addition, the fiber optics system can provide bending strain information which can be used to predict the life of spoolable pipe and the onset of buckling induced lock-up during deployment into a small diameter annulus. [redacted]

Bending strain is represented by the difference in the strain along the longitudinal axis measured at opposite ends of an imaginary line drawn perpendicular to the longitudinal axis of the long slender structure and through the structure centroid. The maximum bending strain occurs on an axis perpendicular to the structure longitudinal axis and perpendicular to the axis of zero bending strain. Fiber optics technology including Optical Time Domain Reflectometry (OTDR), Optical Frequency Domain Reflectometry and Bragg defraction grating methods are ideally suited for in situ measurement of strain in long slender structures. Bragg gratings are particularly valuable for making local strain measurements while the Optical Time Domain Reflectometry method is ideally suited for making global strain measurements such as the average strain over the length of a riser or several risers.

Please add a zero to made a decimal change to (0.0001) in paragraph [007] as shown marked in red below.

[0007] OTDR <u>is a time of flight method which</u> measures spatial positions along an optical fiber by launching brief pulses of laser light into one end of the fiber and then detecting the subsequent

reflections at reflective interfaces inserted along the length of the fiber. The principles of the use of optical fibers technology to measure strain are well established. Discussion of OTDR principles can be found in the following reference, which is incorporated herein by reference: M. K. Barnoski, M. D. Rourke, S. M. Jensen, and R. T. Melville: "Optical Time Domain Reflectometer," Applied Optics, Vol. 16, No. 9. September 1977. The optical fiber is rigidly attached to the long slender structure and thus experiences strain identical to that imposed on the structure. By measuring the transit time of the reflected pulses and by knowing the speed at which light travels in the optical fiber, a very accurate measure of the distance to each reflective interface can be obtained. As the gauge section defined as the length between two reflective interfaces placed within the optical fiber undergoes strain, the interface's spatial position along the fiber changes and the OTDR measurement of this change in length is a direct measurement of the average strain in the structural component. An OTDR with a picosecond pulsed light source can measure a change in length as small as 0.4-inch with an accuracy of about +-.0.001 inch. A change in length of 0.4 in a 70-ft riser converts to a strain of 0.05%.+-.0.[redacted]001%, which is sufficiently accurate to measure strains in the expected range of 0.07%. If needed, the accuracy can be increased in the riser application by making more than one traverse loop along the length of the pipe and thus provide a longer gage length. A single optical fiber can be used to measure strains at more than one location by imposing multiple reflective surfaces along the length of the optical fiber in combination with customized software algorithms to measure strain between each adjacent reflective interface. Measurement of the longitudinal strain in a long slender structure provides valuable information about the state of the "fitness for service" when compared to design allowables and expected conditions.